THE NEED FOR WEATHER INFORMATION FOR SURFACE TRANSPORTATION: *KEEPING THE COUNTRY SAFE AND ON THE MOVE*

INTRODUCTION

The Nation's need for weather information regarding surface transportation reads like a fictional novel.

- Mary and Joe are driving to their in-laws for Thanksgiving, and a major winter snowstorm is forecast…will they get there in time for dinner?
- Vacationers in Florida have heard of a hurricane heading their way…do they evacuate, and if so, what is the best route away from the ocean?
- A college student is planning a road trip for spring break from the northern interior states to southern Texas…he surfs the internet to find the quickest routes which will avoid an ice storm in Iowa and the convective weather in Oklahoma.
- Local businessmen take the ferry to work in the Seattle area, and can't be late for an important meeting…a strong winter storm is approaching…will the winds and waves delay the ferry service today?
- A rural carrier for the United States Postal Service (USPS) is worried about the rain/snow line on his route…will he/she be able to deliver the mail today, as the USPS is known for delivering "in rain or snow"?
- A local television weathercaster in the San Francisco Bay Area gathers information for his Friday night segment to highlight the road conditions over the Sierra Nevada…this will provide the skiers information as they get ready to drive up to the snow for the weekend.
- A truck driver is concerned about his shipment of food perishables which must get to the grocery store in a timely manner…how much additional time will the headwinds add to his trip?

These are just a few examples of how weather affects transportation systems and our lives every day. Weather affects the safety, efficiency, and economic productivity of our transportation systems and facilities.

Why do we need Weather Information for Surface Transportation (WIST)?

Safety
Economics
Human and natural environmental impacts

The number one reason is safety. Nearly every citizen uses some mode of surface transportation daily, whether it be the 3.9 million miles of public roads; 6,200 miles of public transit; 3,750 waterport terminals; 120 thousand miles of major railroads; or the 25 thousand miles of commercially navigable waterways. Many of these transit systems have reached capacity, and inclement weather increases delays, congestion, and system capacity constraints. Directly or indirectly, weather plays a role in 7,000 fatalities resulting from vehicular crashes; the annual estimated economic cost from weather-related crashes (deaths, injuries, and property) amounts to nearly $42 billion. Table 1.1 shows the weather conditions present when vehicle crashes caused injuries or death. Other transportation sectors such as railroads, aircraft, water vessels, and pipelines have far fewer injuries and deaths than occur on roads and highways.

The second reason is economics. Weather can affect a broad range of transportation systems. The freight industry is an example of a weather-challenged business. Each year, about 30 billion tons of domestic and international freight is moved. As an end-to-end system, the freight can begin as a shipment arriving at a port on a ship, transferred to truck, rail, or plane, and moved to your local community store. National roadway systems are affected every day. During the winter months in particular, various state and local agencies spend about $2 billion annually for snow and ice control and another $5 billion for infrastructure repair due to ice and snow. The cost of a one-day highway shutdown due to snow has been estimated at between $15 million and $76 billion in lost time and productivity. In the Sierra Nevada, one overtime shift for the Nevada

Weather Conditions During Vehicle Crashes

Number of Crashes	(percent total)	Weather	Injuries		Deaths	
5,281,000	84%	Normal	2,757,000	(85%)	37,107	(89%)
679,000	11%	Rain	364,000	(11%)	3,086	(7%)
199,000	3%	Snow/Sleet	63,000	(2%)	680	(2%)
47,000	<1%	Fog	18,000	(<1%)	569	(1%)
72,000	1%	Other	34,000	(1%)	275	(<1%)
6,279,000	100%	All Conditions	3,236,000	(100%)	41,717	(100%)

Table 1.1. Statistics comparing crashes, weather conditions, injuries, and deaths.

(Source: NHTSA, 1999)

Article prepared by Ms. Mary M. Cairns, Senior Staff Physical Scientist, OFCM.

Figure 1-1. Images of transportation sectors impacted by weather conditions.

Department of Transportation snow removal crews can cost upwards of $12,000.

A third reason is not as obvious but nonetheless important - the human and natural environment. It is important that the natural environment and communities affected by highway transportation are protected and enhanced. Examples include leveraging the use of weather information to reduce the impact of salting or use of other chemicals for ice treatment on watershed pollution problems, and reducing the impact of highway transportation on the Nation's air pollution problem. Other areas impacted by weather information are the management of roadways on public lands in national forests and national grasslands by the United States Forest Service, and the transportation of nuclear waste.

Clearly the need has been demonstrated for weather information for surface transportation. The question then arose, what steps should be taken to provide this information to the user communities?

In the Beginning

In 1999 the Office of the Federal Coordinator for Meteorology (OFCM) and the United States Department of Transportation (DOT) - Federal Highway Administration (FHWA) brought together leaders of the weather and surface transportation communities. A symposium was held to establish the national needs and requirements for weather information associated with decision-making actions involving surface transportation (OFCM 2000). This was the first time these communities were brought together to address this topic; an unprecedented cross section of more than 120 transportation and weather professionals attended representing federal, state and city governments, urban and rural transportation agencies, professional and trade organizations, and weather service providers (both government and commercial). The goal of the symposium was consistent with the major theme of the Transportation Equity Act for the 21st Century. Then Secretary of Transportation Rodney E. Slater, in his summary message describing this important legislation, stated that *"…transportation is about more than concrete, asphalt, and steel…it is about people, and about providing them with the opportunity to lead safer, healthier, and more fulfilling lives."*

The resulting conclusion supported by all attendees was a proposal to establish a nationwide baseline of weather needs and requirements for surface transportation. The attendees also endorsed the pursuit of solutions that would meet their specific mission needs.

This symposium was an action from the OFCM's Committee for Environmental Services, Operations, and Research Needs (C/ESORN) Joint Action Group for Weather Information for Surface Transportation (JAG/WIST). This interagency group formed under the direction of the Interdepartmental Committee for Meteorological Services and Supporting Research to address mis-

Sectors	Agencies/Entities	Sectors	Agencies/Entities
Airport Ground Operations	Department of Agriculture	Long Haul Railways	Department of Agriculture
	Department of Commerce		Department of Commerce
	Department of Defense		Department of Defense
	Department of Energy		Department of Energy
	Department of the Interior		Department of the Interior
	Department of Transportation		Department of Transportation
	Commercial Airlines		Federal Emergency Management Agency
	Regional Airports		National Aeronautics and Space Administration
			Nuclear Regulatory Commission
			United States Postal Service
			Rail Industry
			Trade Associations
United States Marine Transportation System	Department of Agriculture	Roadways	Department of Agriculture
	Department of Commerce		Department of Commerce
	Department of Defense		Department of Defense
	Department of Energy		Department of Energy
	Department of the Interior		Department of the Interior
	Department of Transportation		Department of Transportation
	Federal Emergency Management Agency		Environmental Protection Agency
	National Aeronautics and Space Administration		Federal Emergency Management Agency
	Nuclear Regulatory Commission		National Aeronautics and Space Administration
	United States Postal Service		Nuclear Regulatory Commission
	Trade Associations		United States Postal Service
			State Departments of Transportation
			Trade Associations
Pipeline Systems	Department of Agriculture	Rural and Urban Transit	Department of Agriculture
	Department of Commerce		Department of Commerce
	Department of Defense		Department of Defense
	Department of the Interior		Department of the Interior
	Department of Transportation		Department of Transportation
	Trade Associaitons		State and Local Transit Authorities
	Energy Industry		Local School Districts
			Trade Associaitons

Table 1.2. Listing of federal departments/agencies and private entities that conduct activities in each of the six transportation sectors.

sion needs and meteorological requirements for surface transportation. The JAG/WIST, with participation by 15 agencies, proceeded with (1) the identification of the agencies and activities that had a stake in this information resource; and (2) the implementation of a survey process to collect data. This process consisted of numerous surveys, questionnaires and interviews. Table 1.2 presents the agencies and entities involved in this process by transportation sector.

An aspect of this process was education. Many of the transportation user community were not as familiar with, or were unaware of, the current advances in weather information that could be applied to operations. Conversely, the meteorological community was awakened to the wide area of needs of various transportation operations. One example of this is weather information for the transport of food by the United States Department of Agriculture (USDA) for school meal plans. The USDA is now cognizant of the various opportunities for accessing weather information, as well as the meteorological community realizing how important weather is for feeding the school children on a daily or weekly basis.

During the needs assessment collection process, a second symposium was held in 2000 (OFCM 2001). The symposium provided the platform for an update on the JAG/WIST activities, the identification of initiatives and programs underway or being planned, and identification of next steps/actions toward improving weather information for decision-makers. The major action items from the symposium included completion and publication of the WIST requirements document; the identification of the need to enhance technology transfer processes; and the identification of the need for a dedicated and focused research and development program.

These activities are summarized below.

WIST Report

The C/ESORN's JAG/WIST is nearing completion of the WIST report (OFCM 2002). This is a comprehensive overview of all the activities to date relating to the needs and requirements for weather information for sur-

Weather Requirements for Roadway Transportation

Weather Element	Threshold	Activity	Impacts	Action	Lead-Time
Freezing precipitation (ice)	Any	Fleet utility and transport vehicle	Safety risk to operators, damage risk, schedule delays	Advise operators, reschedule, reroute	12 hours
		Bus operations	Increased safety risk; passenger injuries and resulting claims, traffic congestion, routes may require detour; delays of scheduled operations, traffic accidents, increased risk of damage to busses/property	Implement preparation procedures, reschedule, reroute, advise operators to drive with extreme caution, modify or restrict operations (especially on hills), suspend operations as appropriate, advise passengers via bus radio system, clear station parking lots and platforms	12-24 hours

Weather Requirements for Waterway Transportation, Inland (rivers, bays, lakes, intercoastal) Open Water

Weather Element	Threshold	Activity	Impacts	Action	Lead-Time
Wind Wave Height (feet)	2 to 4	Inland Recreational Boating	Passenger comfort and risk to small boats	Small boats exercise caution.	12 hours/current
		Open Water Rec Boating	Passenger comfort and risk to small boats	Small boats exercise caution.	12 hours/current
	4 to 6	Inland Recreational Boating, Ferries, and Commerce	Potential risk to crew and passenger safety. Potential for hull damage to small boats. Depending on loading, open barges may take on water.	Exercise extreme caution/stop small boat activities. Advise passengers/modify ferry operations. Reduce speed/suspend operations	12 hours/current
		Open Water Rec Boating, Open Water Cruise Lines	Risk to personnel/possible hull damage. Affects passenger comfort	Boats reduce speed/exercise caution. Advise passengers.	12 hours
		Port Operations	Possible damage to port facilities	Implement Emergency Procedures	12 hours

Weather Requirements for Long Haul Rail Transportation

Weather Element	Threshold	Activity	Impacts	Action	Lead-Time
Air Temperature (°F) (1st occurrence of season)	>70-75	Railway/Control Center Operations Station/Depot Operations Hump Yard Operations Construction Hazardous Materials Surveillance Personnel Safety	First occurrence of season, when air temperature rises to or above 70-75°F, rail expansion causes the maximum number of track warning signals and potential for derailment; possible track sensor/signal sensor malfunction; possible track and/or signal damage; rail inspection crews may be required; signal maintenance crew may be required. Crew, personnel, and passenger safety.	Advise, warn and update dispatch centers, crews, and stations. Predict affected areas, pre-stage resources (equipment and crews). Modify operations to conditions present or forecast; slow or stop train; reroute if feasible; delay departure from station. Review maintenance records to determine areas susceptible to track motion. Inspect/repair tracks, track sensors and signals, as needed. Distribute advisories, warnings, and updates regarding weather situation and track conditions.	3 days
			First occurrence of season, when air temperature rises to or above 70-75°F, rail expansion causes the maximum number of track warning signals and potential for derailment; possible track sensor/signal sensor malfunction; possible track and/or signal damage; rail inspection crews may be required; signal maintenance crew may be required. Crew, personnel, and passenger safety. Hazardous material; monitoring, mitigation; reclamation, reporting.		

Table 1.3. Sample templates of weather information needs for roadway, waterway, and rail operators.

face transportation. Forefront in this report are the actual users' needs and requirements sections, which were gathered from participating agencies, groups, and the private sector. In the identification and validation of the WIST users' needs, several questions were asked:

- Which specific weather elements (a weather event or a condition affected by the weather or related environmental factors) can affect their activities?
- What information about those weather elements (spatial scale, thresholds of severity or proximity, timing of onset and duration) would help the operators and users of those transportation systems to ameliorate negative consequences and take advantage of positive consequences?
- When is the information needed (the lead time of forecasts or the currency of observations) to be most effective in supporting the decision processes of transportation system managers, travelers, and others who decide on transportation activities?

Table 1.3 illustrates a small sample of this information obtained from the railway, waterway, and roadway agencies. Four major conclusions (briefly summarized here) resulted from the compiled needs:

1. The data gathered provide a validated baseline of user-defined weather information needs for a cross-cut of federal, state, and local governmental agencies along with their associated commercial interest groups;
2. The nation can benefit significantly from improved weather informa-

tion for surface transportation in the areas of personal safety and economic benefits;

3. Benefits can be obtained now by increasing the utility of current data and products to existing and potential weather information users; and

4. Substantial benefits to the nation are possible with (a) better spatial and temporal resolutions of both forecasts and observations and (b) improved forecast accuracy.

This report is available from OFCM. Both the public and private sectors can use the information captured in this report to further the efforts for WIST.

Research and Technology

The two symposiums, survey results and interviews provided insight into the current state of research and technology. The WIST report lists research necessary to fill gaps in the knowledge base that supports development of the technology to meet WIST user needs. Examples include the detection and prediction of road/rail conditions in complex terrain; the prediction of precipitation type; land surface modeling; thermal mapping and remote sensing of road contaminants to name a few. Technological development and applied research could help to meet WIST user needs. For example, the development of better computer-based systems for communicating and processing WIST, including the capabilities to integrate total environmental information from air, sea, and land sensors and other sources; the development of "intelligent" decision support systems; and the conduct of human-factors research to improve the human-machine interface, the impact of information, and the standardization of graphical displays in decision support applications are all viable goals.

To date, there has been a limited amount of funding and resources available for WIST (Table 1.4). Of the total amount requested for weather support to operations and supporting research in DOT for Fiscal Year 2003, only 6.3 percent is directed to research related to weather impacts on surface transportation.

However, there are programs currently underway to address some of the needs and requirements targeted in the WIST report. A brief summary of a few of these are provided as examples of how WIST needs can be met.

Intelligent Transportation System (ITS)

The Department of Transportation brings together the concepts of integration, interoperability and intermodalism in this interagency program. The Intelligent Transportation System (ITS) was formulated in the *Intermodal Surface Transportation Equity Act of 1992*. In the last decade, research, operational testing, and demonstrations of benefits were performed to validate the need and use of ITS. ITS is looked at as one of the main mechanisms to be used to bring weather information systems into the transportation community (Figure 1-2) *(www.its.dot.gov/).*

Figure 1-2. Intelligent Transportation Systems will incorporate advances in communications and in-vehicle computing to provide drivers with traveler information on highway construction, road closures, traffic congestion, accidents, and weather that may be ocurring along their route of travel. (Source: ITS-America)

Maintenance Decision Support System (MDSS)

The Maintenance Decision Support System (MDSS) is part of the FHWA Office of Transportation Operations Surface Transportation Weather Decision Support Requirements initiative. The objective of the MDSS is to produce a prototype tool for decision support to winter road maintenance managers. Six national research centers are participating in the development of the prototype MDSS. They include the Cold Regions Research and Engineering Laboratory, the Environmental Technology Laboratory, the Forecast Systems Laboratory, Massachusetts Institute of Technology - Lincoln Laboratory, National Center for Atmospheric Research, and the National Severe Storms Laboratory. The goal is to develop a prototype system whose components will be deployed to road operating agencies, and generally supplied by private vendors (Figure 1-3) (*www.rap.ucar.edu/projects/rdwx_mdss).*

Annual Budget	Weather Operations	Supporting Research
Total DOT: $487 million	$456 million	$30.8 million
Aviation	$443 million	$28.8 million
FHWA	$0	$2.0 million
All Federal Entities:		
$2.84 billion for meteorology	$2.48 billion	$384 million

Table 1.4. Recap of FY 2003 Federal Budget for Meteorology.

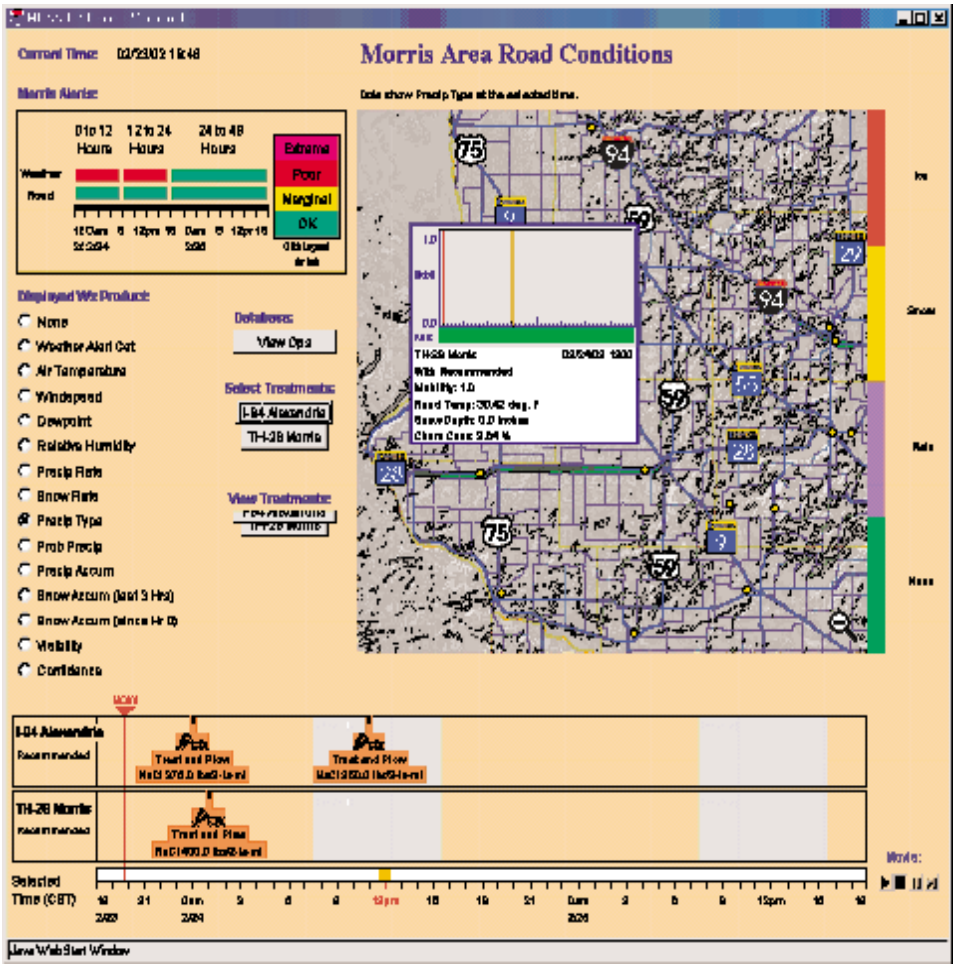

Figure 1-3. Sample display of FHWA's Maintenance Decision Support System (MDSS) (Source: NCAR RAP website).

FORETELL

FORETELL is an initiative covering the Upper Mississippi Valley region funded in part by FHWA, with partners in the state DOTs of Iowa, Wisconsin and Missouri, and the private sector partner Castle Rock Consulting. The goal of the FORETELL field operational test is to create a road weather information system (RWIS) fully integrated within a wider set of ITS services to enhance safety and facilitate travel throughout North America (Figure 1-4). FORETELL collects, forecasts, and distributes highly specific road weather information that is pertinent to highway and trucking professionals, transit operators, everyday commuters, long-distance travelers, and all other road users (*ops.fhwa.dot.gov/Weather/FORETELL/foretell.htm)*.

Other Agencies

Other agency programs can provide a model for a national weather information system (NWIS). The Aviation Weather Research Program, sponsored by the Federal Aviation Administration (FAA) and in coordination with over 50 other FAA offices, federal agencies and organizations, is a good example of an end-to-end program. For surface transportation, the Winter Weather Research Product Development Team focuses on the Weather Support to Deicing Decision Making (WSDDM) system. The objective of WSDDM is to produce real-time, short-term forecasts in the terminal area to support ground deicing and terminal management during winter storm conditions *(www.faa.gov/aua/awr/index.htm*)

The United States Transportation Command has several areas of surface transportation research and concerns. Through the Army's Military Traffic Management Command Transportation Engineering Agency, the Intelligent Road/Rail Information Server is used to provide surface transportation and traffic management services for information used in the mobility of military resources (*www.mtmc.army.mil*).

The Department of Energy's (DOE) National Transportation Program (NTP) is responsible for ensuring the availability of safe, secure, and economical transport services, consistency in regulatory implementation, coordinated outreach, and emergency preparedness assistance for DOE programs. The NTP includes managing a science-based transportation technology program and developing an integrated transportation tool for field applications among a long list of NTP activities (*www.ntp.doe.gov/index.html).*

The National Weather Service (NWS), in partnership with the FHWA and the Cooperative Program for Operational Meteorology, Education and Training, has several cooperative projects targeting a research to operations approach to WIST. One example is a project in Reno, Nevada between the NWS, the Nevada DOT, and the University of Nevada Desert Research Institute. The project is focusing on using the RWIS as input to a data assimilation scheme for a high-resolution mesoscale forecast model. The improved output will be used in several ways: (1) to feed input into a surface temperature forecast model for use in icing and snow removal operations; (2) for initialization of forecast fields in the NWS' Interactive Forecast Preparation System; and (3) to develop a travelers forecast for the public for wintertime road conditions in and around the Sierra Nevada (*www.dri.edu/Projects/Modeling/)*. This is one example of several research and development projects currently taking place across the country.

And Now for the Rest of the Story

Our novel is unfinished - the last chapter waiting for the future. Using our imagination, we can revisit our characters.

- Mary and Joe made it to Thanksgiving dinner after consulting their automobile transportation system mapping the timing of the snow on their route to their in-laws.
- The Florida vacationers tuned in to a dedicated television channel showing the county road evacuation procedures, and how long it would take.
- The college student, with an additional 2 hours to his travel time, arrived at the coast of Texas in time to go surfing on his first day of vacation.
- Our local Seattle businessmen were not late for their meeting, thanks to ferry information they received on their cell phone, advising customers to allow extra time for crossing due to rough seas.
- The USPS rural carrier, after consulting the road pavement forecast for the day, delivered the mail in snow, which was not sticking to the pavement.
- The ski areas in the Sierra Nevada were happy with the crowds on the slopes.
- Our truck driver was able to contact his company for the headwind forecast, which allowed a two-hour layover until the strongest winds subsided, and the deliverables arrived "just-in-time."

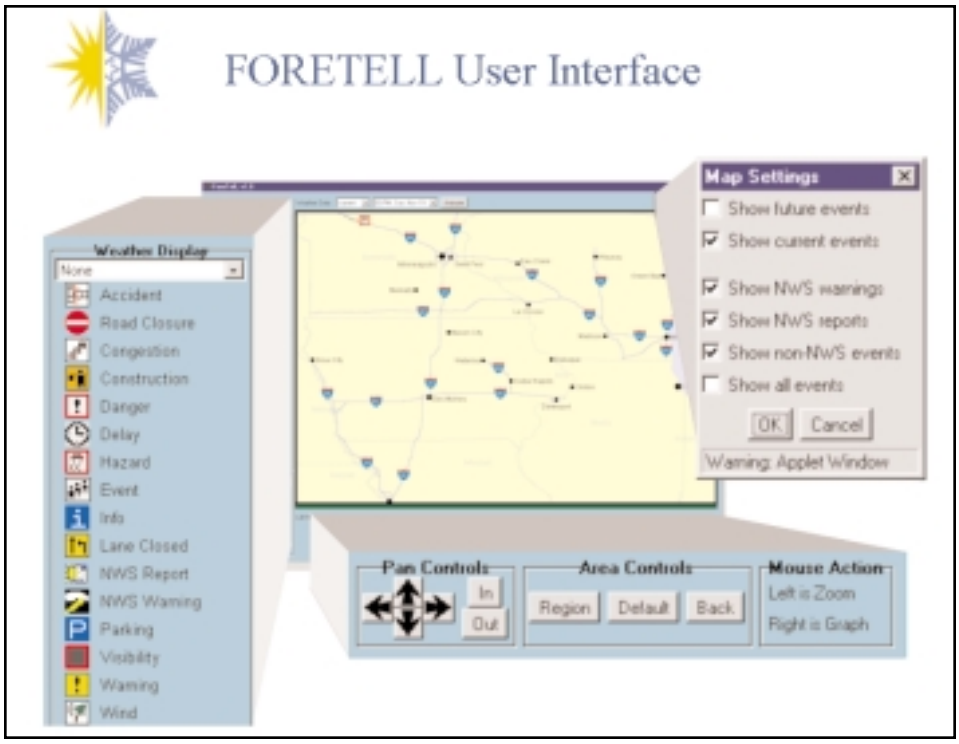

Figure 1-4. FORETELL User Interface.

The possibilities for improving surface transportation for safety and economic value are endless if we continue on this path.

The activities which have taken place over the last several years -- the two symposiums, discussions, and user needs and requirements gathering -- provides an overall framework and general direction for both public and private surface transportation stakeholders. Continued cooperation and coordination will be necessary to achieve the goals of providing weather information for surface transportation. This includes the advocacy of federal research programs, the continuing education of WIST needs for all parties involved, a sharing of technological developments relevant to surface transportation systems, and other interactions between federal, state, and local entities and the private sector to address weather information for surface transportation.

With our Nation's safety at the forefront, and with the advancements in science and technology now is the time to invest efforts for the safety, efficiency, and economic productivity of our transportation systems and facilities.

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